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THE BIOLOGY AND CONTROL OF *MACROPSIS FUSCULA* ZETT., THE VECTOR OF THE RUBUS STUNT VIRUS

DOOR

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CONTROL OF CARROT FLY (*PSILA ROSAE* F.) WITH CHLORDANE IN HOLLAND

DOOR

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The Biology and Control of *Macropsis fuscula* Zett., the Vector of the Rubus Stunt Virus

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ABSTRACT

Rubus stunt, a virus disease of raspberries, has become increasingly prevalent in the Netherlands, particularly in the raspberry production area near Breda. The disease also occurs on wild blackberries; however, it has not yet been found in the Netherlands on cultivated blackberries (Rubus procerus).

Transmission experiments showed that the leafhopper Macropsis fuscula *Zett. is the vector of the virus.*

The biology and control of this leafhopper—which also occurs in Western Canada (Vancouver Island)—is discussed. Relationships between the virus and the vector are mentioned. The Macropsis *fauna of the wild blackberry, being a possible source of virus infection for cultivated raspberries and blackberries, has been studied and is discussed.*

INTRODUCTION

In 1950 Prentice published a paper on the Rubus stunt disease, a dwarfing disease of loganberry, blackberry, raspberry and other cultivated species and hybrids of *Rubus*. The disease is caused by a virus, the Rubus stunt virus. It was first recorded in England by Wormald and Harris (1932). The disease later on became increasingly prevalent in loganberries, Phenomenalberry, blackberries and raspberries in Southern England; it probably affects all *Rubus* species. Infection results in the production of numerous weak, short and thin canes, which give the plant a bushy appearance; later the flowers often show typical proliferations, the floral parts becoming foliar. The incubation period of the symptoms in the field is about one year or even longer (Prentice, 1950; van der Meer, 1954).

Since 1954 the disease also has become increasingly prevalent in the Netherlands on raspberries in the production area near Breda, where it seriously interferes with their commercial cultivation. The disease has been known in that area for about 30 years; since 1945, however, there has been a sudden and rapid increase. Investigations on the spread and control were started in the Netherlands in 1950 by de Fluiter and van der Meer.

RESULTS

Field observations soon indicated that the disease was vector-borne; they also showed that the disease in the Netherlands is common on wild blackberries (de Fluiter and Thung, 1951). In the many experiments carried out with the rubus aphids *Amphorophora rubi* Kalt. and *Aphis idaei* v. d. Goot no transmission of the virus was obtained. The leafhopper, *Macropsis fuscula* Zett., however, appeared to be a vector of the virus (de Fluiter and van der Meer, 1953). Symptoms of Rubus stunt first appeared in June 1953 in a series of experiments, started in July 1952, in which *M. fuscula* was tested as a vector of the virus. The incubation period of the disease on the test plants was in full agreement with the incubation period of the symptoms in the field. In the heavily infested area near Breda the first symptoms of the disease in plantations, planted with healthy plants, appear in late summer or in the autumn of the second year, *viz.*, after the first crop is picked.

Macropsis fuscula Zett., as far as we know, lives only on *Rubus* species. According to literature the insect occurs in Italy, France, Belgium, the Netherlands, Germany, England, Denmark, Norway, Sweden, Finland, and northern Russia. Recently it has been introduced into Vancouver Island, Canada, where it is a pest of loganberry (Andison, *in litt.*).

The biology of *Macropsis fuscula* Zett. in the Netherlands has been studied. The leafhopper passes the winter as an egg on wild and cultivated *Rubus* species. The eggs are laid in the bark of the young canes. Hatching of the nymphs starts in the first half of May in a warm spring or in the second half of May in a cold spring. In the latter case hatching still continues at the beginning of June. The young nymphs feed on the young shoots, the leaf-stalks and the veins of the leaves.

In 1953, when spring was warm, the first adult leafhoppers were already present in the plantations at the end of June; at the end of July most of the *Macropsis* leafhoppers caught were adults. In 1954, with a cold spring, development was somewhat slower (Table I). Adults are present in the plantations during July, August and September. In this period the eggs are laid in the young canes. In September the leafhopper population decreases and by the end of September and the beginning of October very few mature leafhoppers are found on the first-year plants which at that time still bear green leaves.

TABLE I

Date of collecting 1954	Number of leafhoppers (nymphs + adults)	% adults
June 28	323	0.0
July 5	712	2.1
July 12	208	2.8
July 19	609	25.8
July 26	372	45.1
Aug. 2	224	76.3
Aug. 9	812	94.3
Aug. 16	608	99.3
Aug. 23–October 15	692	100.0

The virus is spread by the adult leafhoppers from the old plantations to the new ones. As plantations planted with healthy plants show 50–70% diseased plants by the autumn of the second year, and as the incubation period of the virus is about one year, the adult leafhoppers must be very active in the summer months and able to cover long distances.

That Rubus stunt virus is spread in August and September was shown by the following field experiment, among others:

Seventeen series of 50 healthy, potted raspberry plants of the variety Radboud were grown from virus-free rootstocks on an isolated field at Chaam. Every two weeks from April 16, 1953, a series of 50 plants was taken to a raspberry plantation near Beek, heavily infested with Rubus stunt. The pots were dug into the soil and pots and plants remained in the plantation for two weeks, when they were replaced by the next series. The last series was put in the plantation on October 26. As the plants were removed from the infested field they were carried to an insect-free glasshouse at Breda, where they stayed until the end of the season, in November, 1953, when they were taken out of the pots and planted in the isolated field near Chaam. Three series of check plants were included in the experiment: (a) one series of 50 plants which stayed throughout the season in the isolated field at Chaam; (b) one series of 50 plants which stayed throughout the season in the heavily infested plantation near Beek; (c) one series of 50 plants which stayed throughout the season in the insect-free glasshouse at Breda.

In November, 1953, the plants of the check series b and c were also planted on the isolated field near Chaam.

On November 5, 1954, and on May 26, 1955, the plants of all series were examined for the development of virus symptoms with the following result: Rubus stunt-diseased plants were only present in the series which stayed during the whole season in the heavily infested plantation, and in those series which stayed in this plantation during the periods from July 30 to Aug. 14, Aug. 14 to Aug. 28, and Aug. 28 to Sept. 14. The percentage of diseased plants in these series was 50, 3, 5, and 7 respectively. The period of virus spread thus coincided with the presence of adult *Macropsis* leafhoppers in the plantations.

The relation between virus and vector is still under investigation. The results of the preliminary experiments indicate a rather long latent period and a persistence of the virus in the vector. Five or 10 adult leafhoppers reared on virus-infected raspberry plants were transferred to healthy plants and allowed to feed on them for one to 21 days. Results are given in Table II.

TABLE II

Number of leafhoppers per plant	Date of infection and transmission feeding period						
	28–7–54	29–7–54	3–8–54	4–8–54	5–8–54	26–8–54	27–8–54
	1 day	5 days	1 day	1 day	21 days	1 day	6 days
5	–	–	–	–	x	–	–
5	–	–	–	–	–	–	–
5	–	–	–	–	x	x	x
5	–	–	–	–	x	–	–
5	–	–	–	–	–	–	–
10	–	–	–	–	x	x	x
10	–	–	–	–	–	–	–
10	–	–	–	–	x	–	x
10	–	–	–	–	x	x	?
10	–	–	–	–	x	x	x
10	–	–	–	–	x	–	x
10	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–
10	–	–	–	–	x	–	x

– healthy plant
X Rubus stunt diseased plant (symptoms developed in the autumn of 1955)
? doubtful plant.

CONTROL

Leafhopper control means vector control, which in turn means control of virus spread. Field and laboratory experiments showed that the leafhopper can be controlled by the following schedules:

(a) A winter spray (January or early February) of tar oil 6%, or DNC (Aanitro) 0.4%, or DNC (Trifocide) 0.25%, which kill the eggs (de Fluiter and v. d. Meer, 1955). The winter spray is a very important and effective control measure if applied by *all* growers. We organized a large winter spraying campaign in 1954–55 with the help of the Horticultural Advisory service: the results are now becoming apparent.

(b) A spring spray of parathion 0.1%[1], malathion 0.2%[2], or diazinon 0.1%[2], at the end of May or in the first half of June, to kill the young nymphs. Two applications of any of these materials at the rates given will reduce the leafhopper population greatly in those cases where the grower omitted the winter spray (de Fluiter and ven der Meer, 1956).

(c) Spraying the young, first-year plantations during the critical period of virus spread in August and September to kill the virus-infected adults, and so to prevent infection of the young plantations. It would be very advantageous if a grower could thus protect his first-year plantations, as he would be less at the mercy of neighbouring growers who did not apply winter sprays. With this in mind we started control experiments in 1953, before we knew that *M. fuscula* was the vector of the virus.

Experiment 1. Every two weeks from May 15 to October 15, triplicated plots were sprayed with parathion 0.1%, Systox 0.1%, TEP 0.08%, or DDT 0.3%. A much smaller number of diseased plants appeared in the plots that received parathion or Systox (Table III)

Experiment 2. Systox at 0.1% was applied to triplicated plots every two weeks for varying periods beginning on April 15. Results (Table IV) showed that only those applications after August 1 had reduced the extent of disease. This is in agreement with our knowledge of the biology of the vector, *M. fuscula*.

MACROPSIS SPECIES ON *RUBUS*

We have already mentioned that, in the Netherlands, Rubus stunt is also a common disease of wild blackberries. Is the wild blackberry a source of virus for the cultivated

[1] Only allowed to be applied until 3 weeks before picking.
[2] Allowed to be applied until 10 days before picking.

TABLE III

Insecticide	Diseased plants expressed as % of diseased plants in the check plots (= 100%).
Check	100
Parathion, 0.1%	22
Systox, 0.1%	30
TEP, 0.08%	55
DDT em., 0.3%	96.6

TABLE IV

Sprayed with Systox 0.1% once every two weeks in the period:	Average % Rubus stunt diseased plants
April 15–June 1	43.4
April 15—July 1	44.9
April 15–Aug. 1	37.5
April 15–Sept. 1	15.3
April 15–Oct. 1	16.1
April 15–Nov. 1	21.8
Check plots	34.4

raspberry (*Rubus idaeus*) and the cultivated blackberry (*R. procerus*)? Sampling in the field showed that in the south-western part of the Netherlands, in the province of Zeeland, *Macropsis scotti* Edw. is common on cultivated blackberries and certain species of wild blackberries; so far it never has been found on raspberries. Laboratory experiments showed that *M. scotti* cannot complete development on raspberries; nymphs collected on *R. procerus* and transferred to raspberries soon died. In laboratory experiments carried out by Mr. Pieper, adults of this species always preferred *R. procerus* to *R. idaeus*.

M. fuscula Zett. is very common on cultivated raspberries in the Breda area, where it was also collected from certain species of wild blackberry, viz., *Rubus gratus* and *R. nessensis*. Laboratory experiments showed that nymphs of *M. fuscula*, hatched from eggs laid on raspberries, could develop into adults if reared on the wild blackberries *R. caesius*, *R. macrophyllum*, and *R. silvaticus*.

On *R. caesius* we also found *Macropsis* leafhoppers which differed slightly from *M. fuscula* Zett. In laboratory experiments the nymphs of this "species" developed into adults if reared on *R. caesius*, *R. macrophyllum*, and *R. sylvaticus;* on *R. idaeus*, however, they soon died, which is in accordance with the results of experiments made in previous years.

Summarising, we can say that in the Netherlands *Macropsis scotti* Edw. only occurs on *Rubus procerus* (a cultivated blackberry) and on certain species of wild blackberry. If *M. scotti* Edw. is also a vector of the Rubus stunt virus—a point which is now under investigation—it may be able to transmit the virus from the wild blackberry to the cultivated blackberry (*R. procerus*).

M. fuscula Zett. is a vector of the Rubus stunt virus in raspberries. The fact that the species also can breed and mature on several species of wild blackberries indicates that the wild blackberry can act as a source of virus infection for cultivated raspberries.

The status of the *Macropsis* from *Rubus caesius* is still very doubtful. We are now studying its biology, life cycle and host preferences in order to investigate the part it plays in the spread of virus from wild blackberries to cultivated raspberries, if it is a species not identical with *M. fuscula* Zett.

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DISCUSSION

A. Hartzell. Did you find any evidence of another host in which the symptoms were masked?

H. J. de Fluiter. In the field *M. fuscula* has been found only on *Rubus* spp. In laboratory experiments, however, we transferred *M. fuscula* from diseased raspberries to healthy strawberries. The next year some of these plants showed typical symptoms (a dwarfing and slightly proliferated flowers). The virus could not be transmitted from the infected strawberry plants to healthy ones by the strawberry aphid, *Pentatrichopus fragaefolii*.

Control of Carrot Fly (*Psila rosae* F.) with Chlordane in Holland

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ABSTRACT

The damage caused by the carrot fly, Psila rosae *F., in several parts of the Netherlands has been so severe that control has become absolutely necessary. An effective method has been developed which is now generally applied by the growers of carrots.*

Of several insecticides tested, chlordane has been the most satisfactory.

The carrot fly has been a rather serious pest in various carrot growing centres of Holland. The damage was so severe locally that it was no longer remunerative to grow carrots.

Two categories of carrots are known: (a) the short-growing, slender carrots (type Amsterdamsche Bak or Nantes), which are considered as rather delicate vegetables; and (b) the long-growing, coarser winter carrots (type Flakkeese or Berlikummer), which are used in Holland for consumption on a moderate scale.

The short-growing carrots have a growth period of some three months; the long-growing ones generally develop in about six months. The latter type suffers most from carrot fly damage because of its longer growth period, and a good method for controlling the insect is essential.

The adult flies are present in the carrot fields for extended periods and because the toxicities of the insecticides used to control the insect were short-lived, several applications had to be made every season. This method of control was not economical and attempts have been made to find insecticides which would be toxic for a longer time.

Chlordane was found to give improved control of the carrot fly in Holland, and a larger output of sound carrots was obtained. When the insecticide gave only moderate protection, the reason, in most cases, could be attributed to an insufficiently fine distribution of the actual ingredient into the soil (see also Table II). Chlordane is still being used in Holland in 1956, although cheaper products are in competition with it.

In Switzerland, Günthart (1950) obtained good results in 1947 with an emulsifiable oil of chlordane against the carrot fly and other soil insects. In 1949, Maag (1949) published a pamphlet in Switzerland with directions for using chlordane emulsifiable oil against the carrot fly. He recommended using 300–400 ccs. of the material per 300–400 litres of water per acre, (0.5–0.7 pints per 66–83 Imperial gallons of water per 1/40 acre).

In Holland, we have confirmed these results with chlordane. We use the insecticide as a dust and the results obtained are as good as those obtained with the emulsifiable oil. In our experiments the insecticide was applied by broadcasting the dust over the soil surface. For an even distribution, the dust was first mixed with some moist sand, broadcast, and then worked into the soil with a fork or rake to a depth of not more than 5 cm. (2 inches).

Several experiments were conducted on short-growing carrots in 1951, 1952, and 1953, using this application method. The results obtained are given in Table I.

In the 1951 test, a dosage of 3 grams actual ingredient per m^2 (0.1–0.15 oz. per square yard) was used. Although the dosages were reduced to 1.0–0.75 grams (0.03–0.025 oz. per square yard) in the 1952 and 1953 tests, satisfactory control of the carrot fly was still obtained. Consequently, the recommended dosage for short-growing carrots is now 1 gram actual ingredient per m^2.

In 1952, an experiment using chlordane dust worked into the soil before planting was conducted on short-growing carrots at Sloten and Den Dolder. These carrots were harvested and inspected for carrot fly damage in the early summer; the results obtained are given in Table II. The land at Sloten was fraised (with a rotary hoe) and was spaded at Den Dolder. More carrots were sown on this land immediately without any additional insecticide being applied. These carrots were harvested in late summer and the information obtained on carrot fly injury is given in Table III.

TABLE I—Control of the Carrot Fly on Short-growing Carrots with Chlordane Dust Applied to the Soil Before Planting, 1951–1953.

1951			1952			1953		
Object	Quantity actual ingredient	Percentage of infestation	Object	Quantity actual ingredient	Percentage of infestation	Object	Quantity actual ingredient	Percentage of infestation
	Arnhem			*Arnhem I*			*Arnhem I*	
Untreated		70	Untreated		57,2	Untreated		46,8
Chlordane	3 g/m²	9	Chlordane	3 g/m²	0,5	Chlordane	1,5 g/m²	2,5
			Chlordane	1,5 g/m²	2,1	Chlordane	0,75 g/m²	3,8
				Arnhem II			*Arnhem II*	
			Untreated		35	Untreated		27,5
			Chlordane	1 g/m²	4,5	Chlordane	0,75 g/m²	3,75
				Eindhoven				
			Untreated		16,9			
			Chlordane	1 g/m²	0,25			

TABLE II—Control of the Carrot Fly on Short-growing Carrots in Early Summer, 1952.

Object	Quantity actual ingredient	Percentage of infestation	Object	Quantity actual ingredient	Percentage of infestation
	Sloten I (spring-summer)			*Den Dolder I (spring-summer)*	
Untreated		12	Untreated		86
Chlordane	4 g/m²	3,6	Chlordane	1,5 g/m²	10

TABLE III—Control of the Carrot Fly on Short-growing Carrots Planted on Land that Had Previously been Planted to Carrots (Table IV) and Without Further Insecticidal Treatment, 1952.

Object	Quantity actual ingredient	Percentage of infestation	Object	Quantity actual ingredient	Percentage of infestation
	Sloten II (summer-autumn)			*Den Dolder II (summer-autumn)*	
Untreated		11,7	Untreated		37,8
Chlordane	4 g/m²	0,3	Chlordane	1,5 g/m²	1,4
(only treated for test I in spring)			(only treated for test I in spring)		

Reasonably good protection was obtained on the two successive carrot crops with only one soil application of chlordane. The toxicity of this material to the carrot fly lasted at least 6–7 months. The control obtained in the second test at Sloten and Den Dolder was better than that obtained in the first test although the insecticide had been in the soil for at least three months. These excellent results are due to the tillage (fraising and spading) which gave a better distribution of the insecticide into the soil. On the basis of these results fraising is now recommended.

In 1952, experiments using different application rates of chlordane were conducted on long-growing carrots at Beetgum and Berkhout. An additional test was conducted at Beetgum in 1953 when only one application rate was used. The results obtained from these experiments are given in Table IV.

TABLE IV—Control of the Carrot Fly on Long-growing Carrots with Chlordane, 1952–1953.

Beetgum 1952.

Object	Quantity actual ingredient	Percentage of infestation
Untreated		44,75
Chlordane	3 g/m²	1,5
Chlordane	1 g/m²	9,5

Berkhout 1952.

Object	Quantity actual ingredient	Percentage slight infestation	Percentage heavy infestation	Percentage total infestation
Untreated		4,7	94,5	99,2
Chlordane	1 g/m²	30,2	20,2	50,4
Chlordane	2 g/m²	25,7	10	35,7
Chlordane	4 g/m²	22,0	5	27

Beetgum 1953.

Object	Quantity actual ingredient	Percentage slight infestation	Percentage heavy infestation	Percentage total infestation
Untreated		18	43	61
Chlordane	2 g/m²	6		6

It appears from the results that when infestations of the carrot fly are moderately heavy, 45%–61%, good control can be obtained with a soil treatment of 2 grams actual chlordane per m² (0.06 oz. per square yard). When the infestation is heavy, 90%–100%, as was present at Berkhout, a dosage of 4 grams actual chlordane per m² (0.13 oz. per square yard) is necessary. With this dosage, only 5% of the carrots were heavily infested.

The recommendations for the control of the carrot fly on long-growing carrots based on these and other results reads as follows: In as far as the expected infestations will locally be moderately heavy, 2 grams actual ingredient per m² (0.06 oz. per square yard) should be applied; if a more serious infestation is expected, it is desirable to increase the dosage to 4 grams actual ingredient per m² (0.13 oz. per square yard). The application should be hygienically justified, not only for the grower, but also for the consumer.

In Holland, it is obligatory to print directions for the use of any insecticide on the package containing the material. Information is also given to the grower by Government Services, such as Horticultural and Agricultural Information Services, and the Plant Protection Service.

The hygienical measures necessary to protect the consumer are directed by the Government Institute for Public Health. This institute has determined that carrots treated with chlordane in dosages given in the above recommendations, are not harmful to the consumer.

A number of taste tests on carrots grown on chlordane-treated soil have been conducted in cooperation with the Institute for the Conservation and Preservation of Horticultural Products (Instituut voor Bewaring en Verweking van Tuinbouwproducten) at Wageningen. The tests were conducted on carrots treated with such dosages of chlordane as are usually applied in practice, as well as with larger and smaller dosages. No positive influence on taste could be determined. There is, therefore, no objection to the use of chlordane on carrots if it is applied at the recommended rates.

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